A BEHAVIORAL ECONOMIC ANALYSIS OF DIFFERENT REINFORCERS:

SOUND-CLIPS VERSUS POINTS EXCHANGEABLE FOR MONEY

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Human operant studies frequently use points exchangeable for money as reinforcers. Some studies employ more immediately consumable reinforcers to emulate properties of food reinforcers. This study examined demand for points/money and for sound-clips to compare their economic characteristics. Across four participants, demand was often higher and less elastic for points/money than for sounds. During subsequent exposures at each response requirement, demand for sounds often decreased to a greater degree than demand for points/money. Thus, sound-clips seem less durable than points/money across prices and across repeated exposure to the same price. Response rates for points/money were often higher than for sounds, suggesting that reinforcers that generate higher response rates may be less elastic than reinforcers that generate lower response rates.

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CHAPTER 1

INTRODUCTION

A Behavioral Economic Analysis of Different Reinforcers: Sound-clips and Points Exchangeable for Money

The selection of reinforcers used in human operant experiments is a critical methodological component of basic research; however, little is known about the relative reinforcing effectiveness of the items that have been selected and the variables that affect their reinforcing function. Whereas food is typically used in nonhuman experiments, researchers have used a variety of items as reinforcers in human experiments. Many of these reinforcers are qualitatively dissimilar and thus may have differential effects on operant responding (Rouse, 1999; Shull & Lawrence, 1998). Two qualitatively different items that have been used include points that are later exchanged for money (Catania, Matthews & Shimoff, 1982; Hayes, Brownstein, Zettle, Rosenfarb & Korn, 1986; Joyce & Chase, 1990; Matthews, Catania, Shimoff & Sagvolden, 1977; Rouse, 1999) and sound-clips of music, cartoons, movies and television shows (Rosales-Ruiz, Anderson, Hensley & Koremura, 1999; Rouse, 1999).

During the last three decades, points exchangeable for money (points/money) have been the most common reinforcers used with adult subjects (Galizio & Buskist, 1988). Points/money reinforcers have been used for several reasons. The points can be delivered immediately and with minimal effort, and the money that backs up the points is, in most cases, a powerful reinforcer. However, differences in schedule performance

between humans and nonhumans prompted several researchers to examine more closely this type of reinforcer and to pinpoint the distinctions between points/money and food (for a discussion of these issues see Shull & Lawrence, 1998).

Points/money reinforcers differ from food in several respects. First, points are established as conditioned reinforcers, whereas food is a primary reinforcer. Food is a naturally occurring commodity that is necessary for survival. Also, food is typically consumed following its delivery. By contrast, points acquire their reinforcing function by being paired with an existing reinforcer (money in most studies) or through an instruction specifying the relationship between points and money. Points are not events that are typically "consumed" upon delivery in any conventional sense of the term. Rather, points indicate that a certain amount of the backup reinforcer will be delivered at a later time. As such, the reinforcing effect of points depends on the backup reinforcer and the nature of the exchange delays between points and money (Hyten, Madden & Field, 1994).

A second difference between points/money and food is that points, in many cases, are established as conditioned reinforcers outside of the experimental setting (Rouse, 1999; Shull & Lawrence, 1998). Rouse (1999) suggested that because humans have a long history in which the accumulation of points is associated with accomplishment and winning, points bring an added component of "Earn as many points as you can" to the experiment (p. 3). Whether or not this specific association is learned, humans contact points in a variety of situations, and subsequently, points may carry conditioned reinforcing properties into the experiment. Food, on the other hand, does not derive its reinforcing function through conditioning processes (other than establishing operations),

and thus, any associations with other stimuli outside of the experimental arrangement are not as likely to affect the reinforcing effectiveness of food within sessions.

Third, points/money reinforcers differ from food in that points are often presented as an accumulating total that remains visually displayed throughout the session. Depending upon the study, this type of consequence may provide ongoing feedback as to the total amount of money that the subject has earned. This information also may indicate progress toward completing the session or toward reaching a desired amount of points (Rouse, 1999; Shull & Lawrence, 1998). These types of feedback may affect responding independent of or in conjunction with the backup reinforcer, and as Rouse (1999) suggested, add another source of control to the factors governing reinforcer effectiveness.

In response to these issues, some researchers have advocated the use of reinforcers that more closely resemble food and, in turn, may generate human operant responding that more closely resembles nonhuman operant responding (Rouse, 1999; Shull & Lawrence, 1998). Events that have been used include video games (Case, Ploog, & Fantino, 1990; Miller & Navarick, 1984), story sequences and cartoon-clips (Bentall, Lowe & Beasty, 1985), picture viewing (Navarick, 1986), and sound-clips (Rosales-Ruiz et al., 1999; Rouse, 1999). These events approximate the characteristics of food in that they are immediately consumable events, and they are less dependent on associations with other stimuli for their effectiveness.

Recently, Rouse (1999) investigated the differential effects of points alone, points paired with money, and sound-clips on human schedule performance. Experiment 1 examined the effects of a change in consequence from points with no monetary backup to

sound-clips when responding was maintained on a Fixed-Ratio (FR) 1 schedule of reinforcement. Both types of consequences generated response rates and patterns that were inconsistent across and within several subjects. Rouse concluded that although points alone were effective in the acquisition and maintenance of behavior, points paired with money might generate more consistent performances across and within subjects. In addition, Rouse noted that the higher response rates generated by sound-clips were atypical in that sound-clips consistently produced constant, moderate rates of responding in a previous study (Rosales-Ruiz et al., 1999). She suggested that the exposure to points in a preceding phase could account for this effect. Rouse conducted a second experiment to explore these issues.

Experiment 2 consisted of changing the consequence from sound-clips to points with a monetary backup followed by a return to sound-clips when the behavior was maintained on a FR5 schedule of reinforcement. In contrast to the first experiment, both consequences generated consistent performances across and within subjects, with the exception of one subject's performance during the reversal condition. The decrease in this subject's response rate was characterized by high rates of responding followed by periods with little or no responding whereas the response rates of the other 2 subjects systematically decreased. Overall, points/money generated extremely high rates of responding whereas sound-clips generated moderate rates of responding.

Rouse (1999) suggested that sound-clips may generate response patterns that show more sensitivity to schedule changes than patterns produced by points/money, though she did not directly examine schedule changes. Specifically, she suggested that the moderate rates of responding produced by sound-clips might provide a baseline

performance that is more likely to change systematically with changes in contingencies. Points/money reinforcers, on the other hand, may generate maximal rates of performance that are not affected by many changes in schedule contingencies. Indeed, the elements that comprise points/money reinforcement systems illustrate that points/money are qualitatively dissimilar to sound-clips. Several or all of these factors may account for the differential effects of points/money and sound-clips. However, the way in which these elements influence the reinforcing effectiveness of points remains largely unexamined. This is a topic worthy of investigation because the selection of either of these reinforcers may influence the outcomes of research.

The behavioral economic approach provides a different means of examining the reinforcing function of points/money and sound-clips. This approach can be utilized to measure changes in the reinforcing function of these items across different response requirements. Behavioral economics combines microeconomic concepts, principles, and measures with behavior analytic concepts, principles, and experimental methods (Madden, 2000). It provides alternative independent and dependent measures as well as alternative methods of data analysis (Hursh, 1980, 1984). Behavioral economics provides a method for investigating the relationship between contextual variables and behavior allocation among available reinforcers.

Contextual variables that may influence allocation of behavior for certain items include the quality or quantity of a reinforcer, the number of responses required to obtain the reinforcer, the probability or immediacy of a reinforcer, and the availability of other reinforcers within and outside of the experimental sessions. Microeconomic terms such

as price, consumption, demand, and elasticity are incorporated to describe these variables and their effects on performance (Hursh & Bauman, 1987).

Unit price is one of the main independent variable in behavioral economics. It is a cost-benefit ratio that quantifies the interaction between response requirement, response effort, and reinforcer magnitude, described in a formula by Hursh (1991):

$$\text{Unit Price} = \frac{\text{Responses per reinforcer X Effort}}{\text{Size of Reinforcer}}$$

Thus, the unit price of a reinforcer can be manipulated by changing any of the constituent variables.

It is important to note that application of this concept requires quantification of each constituent variable. In the case of points/money reinforcers, size can be quantified simply by using the number of points per reinforcer delivery. This is a somewhat arbitrary convention, but it ensures a consistent unit price definition. However, determining the reinforcer magnitude for sound-clips proves more difficult, if not impossible. There is simply no metric for the reinforcer magnitude or value of sound-clips comparable to a point count. Furthermore, in practice, a wide array of sound clips is utilized to enhance stimulus novelty, thought to be important in maintaining reinforcer effectiveness with sounds. As a result, the variety of sounds ensures that reinforcing values will vary across sound-clips. Thus, for the purposes of this research, the only way to compare points/money and sound-clip reinforcers will be to examine their effectiveness as a function of response requirement. This does not make use of the complete definition of unit price stated above, but response requirement can still be

considered an important aspect of price, and therefore, a legitimate economic independent variable.

The main dependent variable in behavioral economics is consumption. Consumption simply refers to the number of reinforcers obtained. Response output and response rates are considered secondary measures of behavior. Response output refers to the number of responses an individual will allocate toward the consumption of a particular reinforcer. Although secondary, these measures are important for 2 reasons: a) they are instrumental factors in the control of consumption; and b) this control is indirect in that sometimes these measures are inversely related to consumption. For example, if a 5-minute break functions as a reinforcer for writing one page of a thesis paper and the response requirement for the break increases to 3 pages, this may produce a slight decrease in the consumption of breaks. While consumption of breaks declines, the response output (i.e., the number of written pages) as well as the response rate may increase in an effort to maintain similar levels of break consumption. Thus, all 3 measures provide a clearer picture of interactions between behavior allocation and changing response requirements (see Madden, 2000).

The relation between consumption and price or response requirement is called demand. The law of demand states "all else being equal, consumption of a reinforcer will decrease as its price is increased" (Madden, 2000, p. 8). The demand function is plotted in log-log coordinates yielding a demand curve that indicates the sensitivity of consumption to changes in price.

The slope of the demand curve can be described in terms of elasticity. Elasticity refers to the rate of decrease in consumption relative to initial levels of consumption

(Hursh, 1980). Own-price elasticity measures proportional changes in consumption of one reinforcer across various prices of that reinforcer. Demand is inelastic if large increases in price result in relatively small decreases in consumption (Hursh & Bauman, 1987). In other words, if an increase in price produces a decrease in consumption but an increase in response output, the demand for a reinforcer is inelastic. The personal anecdote described above exemplified inelastic demand. By contrast, when demand for a reinforcer is elastic, increases in price decrease both consumption and response output. In more general terms, demand is elastic if small increases in price result in relatively large decreases in consumption (Hursh & Bauman, 1987). It is common to observe "mixed elasticity" in behavioral economic experiments. Elasticity is considered mixed if demand is inelastic between some (typically low) prices and elastic between other (typically higher) prices.

Elasticity is a property of the demand curve rather than an inherent characteristic of a reinforcer. It is a function of many variables (see Hursh, 1984), and as such, can provide information regarding the effects of these variables on the interactions between responding and amount of reinforcement (i.e., consumption). Elasticity can be quantified by measuring the slope of the demand curve between two prices. Several formulas exist for calculating elasticity coefficients; the formula used in this study will be described in the Method section.

This study will examine effects of various response requirements on the consumption of two reinforcing commodities: sound-clips and points paired with money. The purpose of this experiment is to add to the analysis of reinforcer characteristics by comparing the economic properties of these two different reinforcers. A profile of the

demand curves produced by each reinforcer can reveal how reinforcer effectiveness diminishes as response requirements increase. Similarities or differences in the degree of elasticity (sensitivity to price) between the two reinforcers can help describe how robust each reinforcer is in terms of maintaining behaviors such as remaining in the session and completing increasing response requirements to obtain the reinforcer. These analyses can yield additional, perhaps complementary, information on reinforcer characteristics to that obtained by non-economic analyses of response rate and patterning under schedules of reinforcement.

CHAPTER 2

METHOD

Participants

Four undergraduate students from the University of North Texas participated in this study. Participants were recruited via flyers that were posted in several locations on campus and a newspaper ad that was posted in the school newspaper. The only criterion for inclusion was the participants' ability to manipulate a computer keyboard. Participants received a $20.00 bonus upon completion of the experiment.

Apparatus

The experiment was conducted in a small laboratory room designated for human research experiments. Each participant was alone during all sessions. The apparatus was similar to that used in Rouse (1999). The participants were seated at a table that held a Pentium IBM-compatible computer, monitor, keyboard, mouse and headphones. The target response consisted of pressing a three-key sequence, 1-5-3, in that order on the numerical keypad.

Before the experiment began, a traffic light icon with the green light highlighted was displayed in the center of the monitor. Text that stated, "Press the button to begin" was located just below the icon. Participants clicked on the traffic light with the mouse to begin the experiment.

During the experiment, the monitor displayed a 3 x 3 enclosed grid that was approximately 8 cm^2 and gray in color. The squares within the grid corresponded to the keys 1-9 on the numeric keypad. Each square was approximately 2 cm^2 and separated from the other squares by approximately 0.05 cm. When each session began, all of the

squares appeared “popped up”. During the initial training session, certain squares changed from “popped up” to “pressed in” if the corresponding numeric keys on the keypad were pressed from left to right. Other key presses produced no change in appearance of the squares on the grid. Unlike the apparatus in Rouse (1999), during all subsequent sessions, the squares that corresponded with the 1, 5, and 3 keys were the only squares that changed from “popped up” to “pressed in” if these keys were pressed from left to right. Under all conditions, each 1-5-3 key press produced a click resembling a hopper sound that could be heard through headphones that the subject wore during the experiment.

The monitor also displayed a transparent square approximately 5.5 cm with a black border just below the grid. Under certain conditions, an icon showing an index finger pressing a button would appear in this square following a 1-5-3 key press. Clicking on this icon with the mouse produced either a sound-clip or point-delivery as a consequence. The sound-clips varied in length from 0.38 sec to 7 sec and consisted of sound bytes taken from music, cartoons, movies and television shows. The 283 sound-clips used in Rouse (1999) were incorporated into a larger database of 2,354 sound-clips for this study, resulting in a more varied array of similar types of sound-clips. Each point-delivery was a sound byte that was 1.85 sec in length and consisted of a male voice stating “five points.” Each point was worth 1 cent. The method for delivering the points differed from Rouse (1999) in two respects: (a) each point-delivery was a sound byte rather than a visual display on the monitor; and (b) no accumulating point total was displayed on the screen. These two features of point delivery were designed to equate sound-clips and points with respect to presentation properties. In this way, points had

more of the transient presentation properties of a consumable reinforcer like sound-clips, yet they remained different from sound-clips because of their relationship to the backup money.

Dependent Variables

The dependent variables consisted of the number of sound-clips and point-deliveries earned (which, plotted against response requirements, yielded demand curves) and the number of 1-5-3 key sequences pressed per response requirement (yielding work-rate functions).

Independent Variables

One independent variable consisted of different response requirements, constituting the price element of the behavioral economic analysis. The response requirements were FR5, FR30, FR60 and FR90. A second independent variable was the type of consequence: Points/money versus sound-clips.

Procedure

Participants earned sound-clips during some sessions and point-deliveries during other sessions. During those sessions in which points were delivered, the participants received money at the end of the session equal to the total amount of points they earned.

Training Session. After the participant was seated in front of the computer, the experimenter handed the participant a copy of the training session instructions and read these instructions out loud:

> During this session, you will become familiar with the computer and the experimental procedures. You may earn either sound-clips or points paired with money. The points and the sound-clips will not be presented together in any of

the sessions. If you are earning points then you are earning points only and if you are earning sound-clips then you are earning sound-clips only. Each point is worth 1 cent. You will receive money that is equal to the total amount of points that you earned at the end of the session. You can press any of the nine keys on the numeric keypad. (The experimenter pointed to the keys on the numerical keypad.) When you press the targeted keys, an icon will appear at the bottom of the screen. (The experimenter pointed to the transparent square below the grid.) Press the icon to earn either a sound-clip or 5 points. When you have earned a certain number of sound-clips or points, a computer screen will appear stating "Thank You". This indicates that the session is over. If you would like to quit this session before you have earned the specific number of sound-clips or points, you may press the "Q" button on the keyboard and the session will terminate. (The experimenter pointed to the "Q" button.) There is no penalty for pressing the "Q" button at any point throughout this session. When you are ready to begin, you may put on the headphones in order to hear sound-clips or point-deliveries and press the start button.

If the participant had any questions, the experimenter repeated the relevant portion of the instructions. After reading the instructions and addressing any questions, the experimenter informed the participant that the instructions were posted on the wall and left the room.

Key pressing from left to right was trained with a series of prompts and consequences provided by the computer. When the participant pressed any of the three keys in the left column (i.e., 1, 4, 7), the corresponding square in the on-screen grid

became “pressed in”. If the participant pressed any of the keys in the middle column (i.e., 2, 5, 8) and/or any of the keys in the right column (i.e., 3, 6, 9) *before* pressing one of the keys in the left column, the corresponding squares in those columns did not change in appearance and remained “popped up”. After the participant pressed a key in the left column, the corresponding square remained “pressed in”, and the next change in the grid occurred *only* when the participant pressed one of the keys in the middle column (i.e., 2, 5, 8). In other words, after pressing a key in the left column, key presses in the left and/or right column did not produce any changes in the corresponding squares; only a press in the middle column caused a change in the corresponding square. For example, if the participant initially pressed 5 and 6, then 7, only the square corresponding to the 7 key would become “pressed in”. After pressing the 7 key, if the participant pressed the 1 and 9, then 5, only the square corresponding to the 5 key would change in appearance. The next change in the grid occurred when the participant pressed one of the keys in the right column (i.e., 3, 6, 9). At this point, a square in the left, middle and right columns appeared “pressed in”.

After the participant completed this left-to-right sequence and the corresponding square in the last column (i.e., right column) appeared “pressed in”, the computer would reset and all of the squares would appear “popped up” again. The corresponding squares continued to change from “popped up” to “pressed in” as long as the participant continued to press the keys from left to right. All other key sequences produced no changes in the grid.

In order to produce the sound-clips or point-deliveries, the participant had to make the target response 1-5-3. After the participant pressed the 1-5-3 key sequence, the

corresponding squares remained “pressed in”, a click simulating a hopper sound was produced, and the “index finger touching a button” icon appeared in the transparent square just below the grid. Pressing this icon resulted in a point-delivery or a sound-clip. Each sound-clip was randomly selected from a bank of 2,354 sound-clips. The participants could not continue to press the keys and change the grid until they pressed this icon and heard the point-delivery or sound-clip, unlike the procedure in Rouse (1999). The 1-5-3 squares in the grid remained “pressed in” until the entire sound byte of either the sound-clip or point-delivery was played. The modification of Rouse’s procedure was made to ensure that participants contacted all consequences as they were earned. This was an essential change given that the economic framework of the study focused on the consumption of reinforcers.

During the training session, a FR1 schedule of reinforcement was utilized in which every 1-5-3 key press produced a sound-clip or point-delivery. The session ended when the participant either pressed the 1-5-3 key sequence five consecutive times or pressed the “Q” button. At the end of the session the grid and transparent square disappeared, and text stating “Thank You” appeared in the middle of the screen.

When the participant completed the session by pressing the target response five consecutive times, the experimenter instructed the participant to practice quitting the session. After the participant was seated at the table, the experimenter gave the following instructions:

> Now, I would like for you to practice quitting the session. After you have earned one sound-clip or point-delivery, please quit the session. If you have any questions about how to quit, refer to the instructions posted on the wall.

All participants had to make five consecutive 1-5-3 key presses and practice quitting the session before moving on to the response requirement sessions.

Response Requirement Sessions. The procedures used during these sessions were similar to the procedures used during the training session. Three procedural changes consisted of: (a) the content of the instructions; (b) the number of corresponding squares that changed in appearance when the keys were pressed from left to right; and (c) the number of responses required to earn a sound-clip or point-delivery.

At the beginning of the initial response requirement session, the experimenter handed the participant a copy of the regular session instructions and read these instructions out loud:

> In this experiment, you will have the opportunity to earn sound-clips during some sessions and points exchanged for money during other sessions. The way you can earn sound-clips or points is to press certain keys on the numeric keypad. You can earn up to 120 sound-clips during certain sessions and up to 120 point-deliveries during other sessions. Each point-delivery is 5 points. Each point is worth 1 cent. During each session in which you earn points, you will receive money equal to the total amount of points that you earned at the end of the session. For example, if you earn 600 points in one session, you will receive $6.00 (600 cents) at the end of the session. The purpose of this study is to investigate choice. In each session, you will be able to choose to work as little or as much as you want. You can press the targeted keys as few times or as many times as you want. When you are ready to begin, you may put on the headphones in order to hear sound-clips or point-deliveries and press the start button. If you choose to press the targeted keys, you

may press those keys on the numeric keypad. Incorrect key presses *will not* count against you in any way. While pressing the targeted keys, you may notice an icon that will periodically appear at the bottom of the screen. In order to hear the sound-clip or the point-delivery that you have earned, you must press the icon. If you want to end the session at any time, you may quit by pressing the "Q" button on the keyboard and the session will terminate. There is no penalty for pressing the "Q" button at any point throughout the session. During those sessions in which you are earning points, you will be paid the amount of money that equals the total amount of points that you earned up to the time that you pressed the "Q" button. You may also take short breaks at any point throughout the session to use the bathroom or to get a drink of water. Do not press "Q" if you want to take a break. You may simply stop and leave the computer screen as it is. When the session ends, a computer screen will appear that states "Thank You". Please remember, there is no right or wrong way to respond. It makes no difference to the experimenter what you choose to do. The number of targeted keys you press is entirely up to you.

At the beginning of all subsequent sessions the experimenter stated, "The instructions are posted on the wall. Remember, you can earn as many or as few points or sound-clips as you would like."

During these sessions, the left-to-right prompting procedure was removed. In Rouse (1999) this prompting remained in effect, but it was deemed unnecessary and possibly confusing to participants, so it was removed in the present procedure.

After the participant began the experiment and the grid was displayed, the 1, 5, and 3 squares were the only squares that changed from "popped up" to "pressed in" if those numeric keys were pressed from left to right.

The response requirement conditions consisted of FR5, FR30, FR60, and FR90. The FR schedules determined the number of 1-5-3 key presses required to produce either a sound-clip or point-delivery. For example, the participant had to make five 1-5-3 key presses to earn a sound-clip under a FR-5 response requirement with sounds as consequences, and 30 1-5-3 key presses to earn a point-delivery under a FR-30 response requirement with points as consequences.

During each session, the participant could earn a maximum of 120 sound-clips or 120 "5 point" deliveries. Financial constraints required that earned money be limited to 120 deliveries ($6.00) per session, so the number of sound-clip deliveries was also limited to 120. Each session ended when the participant either earned the total amount of sounds/points or pressed the "Q" button and terminated the session.

Experimental Design

During the training session, 1-5-3 key presses produced point-deliveries for participants S1 and S4 and sound-clips for participants S2 and S3. All participants were exposed to sessions with sound-clips and point-deliveries as consequences under all response requirement conditions. The response requirement sessions were quasi-randomized. Thus, the experimental design could be characterized as a multi-element design (two consequence types) with parametric exposure to different response requirements. The experimenter flipped a coin to determine the order in which sessions with sound-clips as consequences and sessions with point-deliveries as consequences

would be presented for all subjects. The response requirement conditions with sound-clips and point-deliveries were presented in the order shown in Table 1.

The sequence was designed so that all subjects would be exposed to every response requirement with each consequence type at least once. Additional exposures to each response requirement and consequence type were not possible for all subjects. Some second and third exposures were programmed when consumption data on earlier exposures was unusual or unstable and the participant was still available.

Data Analysis

Several measures of behavior were analyzed, including the number of responses per session at a given price (response output), response rates, and consumption in terms of the number of obtained reinforcer deliveries as a function of price (demand). Own-price elasticity of consumption for points and sound-clips was calculated yielding elasticity coefficients. The following equation derived from Samuelson and Nordhaus (1985) was used:

$$\text{Elasticity} = \frac{\text{Delta Q}}{(Q1 + Q2) / 2} \Big/ \frac{-\text{Delta P}}{(P1 + P2) / 2}$$

where Delta Q is the change in the quantity consumed of either points or sound-clips, Q1 and Q2 are the quantities consumed under price 1 and price 2 respectively, Delta P is the change in response requirement, and P1 and P2 are the 2 response requirements. Elasticity coefficients equal to or greater than 1.0 indicate elastic demand whereas elasticity coefficients less than 1.0 indicate inelastic demand.

CHAPTER 3

RESULTS

Table 1 contains data on session length in each condition for all subjects. Participant S3 has "no data" indicated during the first training session because the computer lost the data. The session length varied considerably across all conditions and across all subjects. The session length for Subject 1 ranged from 21 s (in session 18 with FR5 for points/money) to 21.3 min (in session 3 with FR30 for sound-clips). The session length for Subject 2 ranged from 3.7 min (in session 12 with FR30 for points/money) to 21.83 min (in session 5 with FR60 for points/money). Sessions for Subject 3 ranged from 1 min (in session 14 with FR60 for sound-clips) to 45.29 min (in session 6 with FR60 for points/money). The session length for Subject 4 ranged from 8.4 s (in session 11 with FR 30 for sound-clips) to 40.54 min (in session 5 with FR30 for points/money). The high degree of variability across conditions for each subject indicates that they were not terminating the sessions after any constant time. Had session durations remained roughly constant across sessions, it might have suggested that subjects were self-imposing a time limit. Such a self-imposed ceiling on session duration would, as a result, yield artificially decreasing demand curves.

Demand curves and response output functions are shown for each subject in Figures 1-4. Tables 2-5 show elasticity coefficients, consumption (number of reinforcers obtained out of the maximum 120), response output (number of responses emitted out of a maximum of 600 at FR5, 3,600 at FR30, 7,200 at FR60, and 10,800 at FR90),

responses per minute, and money earned during each condition for each subject. Response rate data (shown in Figures 5-8) will be discussed after the economic measures.

In general, demand curves for all subjects showed decreasing consumption as response requirements increased. Three out of the four subjects showed important differences between the demand curves for points/money reinforcers and sound-clip reinforcers. During response requirement replications (second and third exposures to a given requirement), demand for sound-clips decreased, often decreasing to a greater degree than the reductions in demand for points/money. For all 4 subjects, response output was bitonic (peaked at a particular price) for points/money reinforcers. Response outputs for sound-clip conditions were more variable, showing large differences between first and subsequent exposures to the same response requirement.

Figure 1 shows the demand curves (top graph) and response output functions (bottom graph) of sound-clips and points/money under all response requirements for participant S1. During the first exposure to each of the four response requirements, consumption of both sound-clips and points/money was at maximum at FR5, but became elastic between FR30 and FR60 (indicated by the elasticity coefficients of 2.64 and 2.5, respectively). Demand for sound-clips was higher than demand for points/money at FR30 and FR60. Consumption of sound-clips decreased from 63 with a response output of 1890 responses at FR30 to 4 with a response output of 250 responses at FR60. Consumption of points/money decreased from 22 with a response output of 660 responses at FR30 to 2 with a response output of 120 responses at FR60. At FR90, S1 consumed two points/money reinforcers but only one sound-clip reinforcer.

During the second exposure, S1 consumed 120 points/money reinforcers but only 77 sound-clips at FR5. Consumption of both sound-clips and points/money became elastic between FR5 and FR30, but consumption levels at FR30 were higher for points/money (14 point deliveries) than for sound-clips (2 sounds). Consumption levels at FR60 and FR90 were minimal (1 reinforcer) for both sound-clips and points/money. A third exposure to FR5 and FR30 revealed that consumption levels were identical to second exposure levels for points/money, but extremely low (3 reinforcers in each case) for sound-clips.

Response output data were consistent with the effects seen in the demand curve for S1. Initially, response output was highest at FR30 for both sound-clips and points/money. S1 emitted 1890 responses in the sound-clip condition and 660 responses in the points/money condition at FR30. Second and third exposures showed much lower response outputs for sound-clips than for points/money.

Figure 2 shows the demand curves (top graph) and response output functions (bottom graph) for participant S2. This participant's consumption remained higher at the large response requirements than the consumption of S1, producing a flatter demand curve. During the initial exposure to each of the four response requirements, consumption of sound-clips became elastic between FR30 and FR60 (indicated by the elasticity coefficient of 2.45), whereas consumption of points/money became elastic between FR60 and FR90 (elasticity coefficient = 1.05). Consumption of sound-clips decreased from 59 sound-clips with a response output of 1770 responses at FR30 to 6 sound-clips with a response output of 398 responses at FR60. This relatively high consumption of sound-clips at FR30 was similar to that of S1. It may be important to note that this was only the

third session for all participants. Consumption of points/money decreased from 23 point deliveries with a response output of 1380 responses at FR60 to 15 point deliveries with a response output of 1350 responses at FR90. Oddly, consumption of sound-clips increased at FR90 from the level at FR60 (yielding a negative elasticity coefficient of –2.0).

The second exposure to the response requirements yielded demand curves that were similar for points/money and sound-clips. Consumption of points/money was slightly higher than that of sound-clips at FR30 and FR60. Consumption of both sound-clips and points/money became elastic between FR5 and FR30 with elasticity coefficients of 1.33 and 1.05, respectively. Demand was also elastic for both commodities between FR60 and FR90 with elasticity coefficients of 1.4 and 2.5, respectively. Third exposures to FR5 and FR60 for both commodities yielded lower consumption levels for sound-clips than for points/money. These effects are mirrored in the response output data shown in the bottom graph.

Figure 3 shows the demand curves and response output functions (bottom graph) for participant S3. During the first exposure to the response requirements, consumption of sound-clips and points/money was maximal at FR5 and FR30. Consumption of sound-clips became elastic between FR30 and FR60 as indicated by the elasticity coefficient of 1.8. Consumption decreased from the maximum 120 sound-clips, with a response output of 3600 responses at FR30, to 30 sound-clips with a response output of 1800 responses at FR60. Consumption of points/money decreased only slightly between FR30 and FR60. Consumption at FR90 was under 10 reinforcers for both sound-clips and points/money.

During the second exposure, demand for both sound-clips and points/money became elastic between FR30 and FR60, but consumption levels were higher for

points/money than for sound-clips at FR30 and especially FR60. Consumption of sound-clips decreased from 93 sound-clips with a response output of 2808 responses at FR30 to 2 sound-clips with a response output of 136 at FR60. Consumption of points/money decreased from the maximum of 120 point deliveries, with a response output of 3600 responses, to 57 point deliveries with a response output of 3476. Response output data was clearly bitonic in character for both reinforcers, but output peaks during the initial exposure occurred at a lower response requirement for sound-clips than for points/money.

Participant S3 was the only subject to consume the maximum amount of sound-clips during the initial exposure to FR30. Of all the participants, S3 also consumed the largest amount of sound-clips during the initial exposure to FR60 and the second exposure to FR30. Also, unlike S1 and S2, this participant consumed the maximum amount of points/money during the initial exposure to FR30. S3 consumed the largest amount of points/money during both exposures of FR60 and the second exposure to FR30 of all participants.

Figure 4 shows the demand curves and response output functions for participant S4. Consumption levels for sound-clips were consistently lower than that of points/money reinforcers at every one of the four response requirements. S4 only consumed 45 sound-clips in the first exposure to FR5, lowest of all other participants at this response requirement. Consumption of sound-clips became elastic between FR5 and FR30 as indicated by the elasticity coefficient of 1.15. Consumption of points/money became elastic between FR30 and FR60 as indicated by the elasticity coefficient of 1.12. Consumption of points/money decreased from the maximum amount of 120 point deliveries at FR30, to 55 point deliveries with a response output of 3300 responses at

FR60. Consumption of points/money decreased substantially at FR90, but remained above that of sound-clips.

A second exposure to FR5 and FR30 for sound-clips yielded minimal levels of consumption, whereas a second exposure to FR5 for points/money yielded maximum consumption (120 point deliveries). Unfortunately, a second exposure to higher response requirements for points/money reinforcers was not possible for this participant.

Figures 5-8 show response rate data for sound-clips and points/money across all sessions in the order of the sessions. Data are plotted in this manner, rather than as a function of response requirements, because differences between rates for the two reinforcers can be seen as well as changes across the experiment. To re-construct the relation between response rate and a given response requirement in effect, one need only consult Table 1.

In general, response rate data provided little useful information. Response rates did not vary systematically as a function of the response requirement in effect. In many cases, session durations were so short that 30-40 seconds difference drastically affected response rates. A good example can be seen in Figure 5. Sessions 15 and 16 have identical response requirements (FR90) and in each session only one reinforcer was consumed, yet the session durations were so short (.72 min for session 15 and 1.42 min for session 16) that the rates differed considerably. Two common effects can be observed. First, for participants S1 and S2, response rates were faster toward the end of the experiment than at the beginning, indicating possible practice effects. Second, for all participants, response rates under the point/money condition were often higher than under the sound-clip condition. The highest rates produced by each subject occurred during

sessions with the points/money reinforcers. The most extreme example of this occurred for S3 in session 8 (Figure 7; second exposure to FR5 for points/money, preceded by an FR5 for sound-clips in session 7). Participant S3 produced the highest response rate observed for any participant (note the re-scaled vertical axis) with nearly 408 responses per min to consume the maximum 120 point deliveries.

Table 6 shows repetition of sound-clips across subsequent response requirement sessions. The number of sound-clips that were repeated out of the total number of sound-clips consumed yielded a percentage of sound-clip repetition at each response requirement for all participants. Overall percentages for participants S1, S2, S3, and S4 were 2.91%, 6.93%, 7.33%, and 0%.

CHAPTER 4

DISCUSSION

The results of this study show that there were substantial differences between demand for sound-clips and points/money. These differences can be seen in several aspects of responding. First, across multiple exposures to the same response requirement, consumption of sound-clips decreased compared to minimal decreases in consumption of points/money. For participants S1, S2, and S4, consumption at the lowest response requirement (FR5) was below the maximum during later exposures, something never observed for points/money at this price. When consumption of sound-clips exceeded that of points/money at a given response requirement during the first exposure, as it did at several prices for S1 and S2, later exposures produced consumption levels lower than that for points/money. Second, response outputs in sound-clip conditions were either more variable between replications or flatter than the more conventional bitonic response output functions in points/money conditions. In general, points/money produced demand that was more consistent across replications at the same response requirement than demand for sound-clips. Furthermore, demand for points/money was often higher than demand for sound-clips.

Although sound-clips yielded higher demand than points/money during the initial exposures to FR30 and FR60 for participant S1 and the initial exposure to FR30 for participant S2, consumption of sound-clips for both participants decreased and was lower than points/money during subsequent exposures of these response requirements. Two

types of sequence effects could potentially account for the fact that initial levels of sound-clip consumption were higher than that of points/money. First, the sound-clips were introduced before points/money during both FR30 and FR60. Indeed, the participants were exposed to sound-clips at FR30 and FR60 before being exposed to points/money at FR30. Second, the FR30 and FR60 sound-clip conditions (sessions 3 and 4, respectively) occurred relatively early in the experiment. At this point the participants may have been less apt to quit the session because the experimental setting was still somewhat novel.

Economic data gathered by Reyes (2000) suggest that sequence effects may influence demand. The multi-element design used in this study ensured that conditions changed rapidly from session to session, opening the possibility of sequence effects. An improved multi-element design would counterbalance the order of the exposure to points/money and sound-clips to examine possible sequence effects. Other designs could have been used, but they would have presented their own problems. For example, a design in which some subjects were exposed to the range of prices for sound-clips followed by exposure to the range of prices for points/money might have caused subjects exposed to the sound-clip phase to quit the entire experiment before they contacted the points/money phases. Group designs can eliminate some sequence effects, but would require more subjects per condition so that between-group effects can be observed above levels of intersubject variability. Further study of comparisons between reinforcing commodities could benefit from examinations of sequence of exposure to different conditions.

The decreases in consumption as response requirements increased seen in the demand curves for all subjects is predicted by the law of demand (Madden, 2000). These

findings are consistent with a number of behavioral economic analyses of other reinforcers, including points/money and certain drugs (see Bickel, DeGrandpre, Hughes, & Higgins, 1991; Bickel, Hughes, DeGrandpre, Higgins, & Rizutto, 1992; DeGrandpre, Bickel, Higgins, & Hughes, 1994; Green & Kagel, 1996; Hursh, Raslear, Shurtleff, Bauman, & Simons, 1988; Reyes, 2000). In all cases, both commodities were sensitive to price manipulations, but sound-clips showed greater sensitivity either during initial exposures to prices (as was the case for S3 and S4) or during subsequent exposures (as was the case for S1 and S2).

Sensitivity to contingency changes is a desirable feature of behavior from the standpoint of conventional reinforcement schedule research (Vaughan, 1989), but there are different meanings of the term sensitivity (Madden, Chase, & Joyce, 1989). In the economic framework of this study, sensitivity to contingency changes refers to the elasticity of demand. The fact that sound-clips are, in many respects, more elastic than points/money consequences is not necessarily a desirable feature.

The relatively high levels of demand for sound-clips at FR5 during the first two exposures for participants S1, S2, and S3 and during the third exposure for S3 indicate that sound-clips may be reasonably effective reinforcers in the maintenance of behavior under low response requirements. However, the decrease in demand for sound-clips across increasing response requirements and subsequent exposures of the lower response requirements for participants S1, S3, and S4 indicate that sound-clips, as reinforcers, may not be durable or generalize across conditions that require more responding or more effortful responses. Points/money, on the other hand, appear to be more durable across

these types of conditions. This conclusion might be very important to researchers considering whether to use points/money or sound-clips in certain kinds of studies.

It is important to note, however, that demand for points/money was elastic between FR5 and FR30 during the second exposure for participants S1 and S2. As noted earlier, elasticity is not an inherent property of the reinforcer, but rather a function of the interaction between contextual variables and the physical characteristics of the reinforcer. It is possible that the arbitrary selection of the 5-point reinforcer magnitude was not a sizable enough amount to maintain responding at higher response requirements. Larger magnitudes of points/money reinforcers could be examined in future studies by comparing the effect of identical unit prices composed with differing reinforcer magnitudes (as was studied in preliminary fashion by Viken, 1999).

Across all participants, points/money conditions often generated higher rates of responding under changing response requirements than did sound-clip conditions. This finding is similar to response rate differentials in the same direction observed in Rouse (1999). In the present study, there seems to be no systematic relation between response rates and particular levels of demand for either reinforcer, other than the general correlation of higher demand and higher response rates that occur under points/money conditions. The fact that demand for points/money reinforcers became elastic as response requirement increased indicates that high response rates clearly do not lead to a lack of sensitivity to changes in the experimental contingencies. On the other hand, it does suggest that commodities that generate high response rates may be less elastic than commodities that generate lower response rates under similar conditions.

Overall, the results support the notion that the qualitative differences between these two types of reinforcers may lead to their differential effects on operant responding (Rouse, 1999; Shull & Lawrence, 1998). Rouse (1999) suggested that the types of feedback inherent in common methods of point presentation add a potential source of control to the factors governing its reinforcing effectiveness. Interestingly, the change in the points/money reinforcement system from a visual accumulation display used in Rouse (1999) to a more transient presentation did not seem to diminish the demand for this reinforcer. All efforts were made in the present study to equate presentation aspects of sound-clips and points in an attempt to isolate the relationship between points and money as the one characteristic that distinguishes points/money consequences from sound-clips. The results indicate that this component may be the critical factor in the reinforcing effectiveness of points/money apart from presentation aspects, but an explicit comparison of point presentation aspects would need to be conducted within the same experiment to examine this issue conclusively.

Additional sources of control with sound-clips may also factor into their reinforcing effectiveness. Experimenters sometimes utilize extra-experimental contingencies to entice participation in the study and to ensure that participants attend the required amount of sessions. One type of contingency outside of the experimental session includes paying participants per session regardless of performance, as an attendance contingency. Galizio and Buskist (1988) suggested that these additional components of the experimental preparation could influence the programmed reinforcement contingencies within sessions. Rouse (1999) utilized this payment system with points alone and sound-clips. It is possible that the moderate rates generated by

sound-clips in her Experiment II were due to this extra-experimental contingency rather than the effectiveness of the sound-clips in maintaining this performance. In contrast to Rouse (1999), participants in this study were not given monetary payment for attending the sessions with sound-clips as consequences. This lack of payment for attendance could have accounted for the general decrease in levels of sound-clip consumption across subsequent sessions. Indeed, the initial demand for sound-clips and demand curves for participant S4 indicate that sound-clips by themselves functioned only weakly as a reinforcer for his behavior. Again, future studies could examine the effectiveness of sound-clip reinforcers with and without attendance money payments.

It is possible that habituation due to repeated exposure to sound-clip stimuli accounts to some degree for their diminishing demand across repeated price exposures. Habituation would not play a role in the effectiveness of points/money reinforcers because the relationship to money is not affected by repeated exposure to the point deliveries. For sound-clips, it is possible, even likely, that stimulus novelty plays a role in their reinforcing effectiveness. However, this factor alone cannot account for the lower demand for sound-clips in any simple fashion. The database of sound-clips used in this experiment was large, larger than in Rouse (1999), to make it less likely that participants would repeatedly be exposed to the same sound-clips across sessions. It is possible that a more complex "second-order" habituation effect was operating, in that repeated exposure to sound-clips as an entire class of stimuli, or to certain subclasses of related sound-clips, diminished their value. Some sound-clips in the present study were related in that they originated from the same source (e.g., the same television shows). Future studies could

use databases of sounds that differ in systematic ways (such as in the degree of relatedness of their constituent sound-clips) to explore this issue.

The lack of research in reinforcer effectiveness provides a wide range of investigative possibilities. Tustin (1994) noted the importance of utilizing a behavioral economic perspective in the applied area to gain information about the durability of reinforcers across increasing response requirements. He tested this type of measurement with data gathered under a concurrent reinforcer paradigm in which the schedule of one of the reinforcers was varied. The results of his analysis with three case studies indicated that one of the reinforcers that was preferred under low schedule requirements was no longer preferred when the schedule requirements increased. For the same reasons, the behavioral economic approach can be utilized to gain information about the reinforcers that are employed in basic human operant research. The results of the present study indicate that our knowledge of reinforcer effectiveness under a variety of changing conditions needs to be expanded.

Changing response requirements are a kind of price manipulation, but price is only one example of economic variables that can be manipulated. The effects of other variables such as the availability of alternative reinforcers and the immediacy of the reinforcer can be systematically examined utilizing the behavioral economic approach. Economic concepts such as substitutability and complementarity offer new tools for understanding reinforcer effectiveness when reinforcers interact to affect demand or choice (see Green & Freed, 1993). An extension of the present study might be to examine choice for points/money and sound-clip reinforcers when both are presented concurrently under changing response requirements.

APPENDIX A

RECRUITMENT FLYER,

INFORMED CONSENT FORM,

DEBRIEFING QUESTIONS

CASH
SOUND-CLIPS
AIR-CONDITIONING

INTERESTED?

You can earn money and listen to some sounds in a cool environment THIS SUMMER

HOW?

Participate in an experiment on human learning!

Call Debi at 565-3538 OR 484-5137 & leave message.

This project has been reviewed and approved by the UNT Committee for the Protection of Human Subjects (940-565-3940

Debi 565-3538 or 484-5137

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Informed Consent Form

My name is Debi Alvey, and I am a graduate student at the University of North Texas. I am requesting your consent to participate in a research study. The results from this study will be presented at a conference.

Please read the following consent form carefully before signing.

I understand that taking part in this experiment will last for a minimum of 20 sessions (approximately 4-5 weeks.) Only one session will be conducted each day of participation. I will earn varying amounts of sound-clips during some of the sessions. During other sessions, I will earn varying amounts of points that will be exchanged for money at the end of that session. Also, I will obtain a $20 bonus upon completion of the 20 sessions. After the experiment, I will be debriefed and be able to ask questions regarding the experiment. Benefits of participation include the potential for earning sound-clips during some sessions, points paired with money during other sessions, and a $20 bonus for completing the experiment. By taking part in this experiment, I personally will not benefit psychologically or physiologically. However, my participation may result in information regarding behavioral choice processes that will benefit society at large. There are no foreseen risks as a result of participating in this study.

I have been informed that any information obtained in this experiment will be coded by use of arbitrary numbers and the data will be kept locked up without access to anyone but the experimenters. Under these conditions, I agree that any information obtained in the study may be subject for publications and public presentations. Participation in this study is voluntary and I have a right to view data at the conclusion of the experiment and determine to discontinue my participation at any time without penalty, prejudice, or loss of benefits.

I will be provided with a copy of this informed consent form for my records. If I have any questions or problems that arise in connection with the participation in this study, I will contact Debi Alvey at (940) 565-3538 (Department of Behavior Analysis) or Dr. Cloyd Hyten at (940) 565-4071 (Department of Behavior Analysis).

Name of participant (please print):

_____

_____ _____

Date Signature of Participant

_____ _____

Date Signature of Principal Investigator

Debriefing questions

1. What do you think the purpose of this experiment is?

2. What made you decide how many sound-clips you would earn?

3. What made you decide how many points that you would earn?

4. How important was it for you to earn the sound-clips?

5. How important was it for you to earn the points?

6. What was the main motivator for you to complete the experiment?

7. Did you at any point want to stop coming to the experiment?

8. Did you ever run out of time or get in a rush for other things while you were participating in the experiment?

9. What did you usually do after you finished the sessions?

10. Did anything outside of the experiment influence the way that you responded during any of the sessions?

APPENDIX B

TABLES

Table 1. Condition sequence and session length in minutes for each participant

Condition Sequence and Session Length in Minutes for each Participant					
		Participants			
Session	Condition	S1	S2	S3	S4
Training	FR1 Sound-clips	~	6.92	no data	~
	FR1 Points	2.18	~	~	5.31
1	FR5 Sound-clips	12.3	7.77	10.26	2.89
2	FR5 Points	8.14	8.46	3.04	6.24
3	FR30 Sound-clips	21.3	20.39	24.66	2.11
4	FR60 Sound-clips	4.7	6.17	13.14	1.2
5	FR30 Points	6.46	8.56	24.12	40.54
6	FR60 Points	2.56	21.83	45.29	27.04
7	FR5 Sound-clips	3.92	4.79	2.26	0.14
8	FR5 Points	5.47	4.52	1.47	5.28
9	FR90 Sound-clips	1.16	17.32	4.46	0.93
10	FR90 Points	2.11	13.61	2.66	10.8
11	FR30 Sound-clips	1.61	3.98	14.21	0.31
12	FR30 Points	3.21	3.7	19.63	~
13	FR60 Points	1.55	8.7	19.9	~
14	FR60 Sound-clips	0.72	9.18	1	~
15	FR90 Sound-clips	1.42	6.81	~	~
16	FR90 Points	0.78	4.89	~	~
17	FR5 Points	4.39	4.47	~	~
18	FR5 Sound-clips	0.35	4.07	~	~
19	FR60 Sound-clips	~	4.87	~	~
	FR30 Sound-clips	0.85	~	~	~
20	FR60 Points	~	14.81	~	~
	FR30 Points	2.73	~	~	~

Table 2. Elasticity coefficients, consumption, response output, responses per minute, and money earned during each condition with sound-clips and points/money.

Participant S1						
Reinforcer	Condition	Elasiticity Coefficient	Consumption	Response Output	Responses per Minute	Money Earned
Sound-Clips	FR 5		120	600	48.79	
	FR30	0.44	63	1890	88.73	
	FR60	2.64	4	250	53.19	
	FR90	3.00	1	100	86.46	
	FR5 replication		77	385	98.30	
	FR30 replication	1.33	2	60	37.24	
	FR60 replication	1.00	1	60	83.41	
	FR90 replication	0.00	1	90	63.60	
	FR5 replication #2		3	15	42.43	
	FR30 replication #2		3	90	105.59	
Points/ Money	FR5		120	600	73.74	$6.00
	FR30	0.97	22	660	102.13	$1.10
	FR60	2.50	2	120	46.83	$0.10
	FR90	0.00	2	180	84.97	$0.10
	FR5 replication		120	600	109.68	$6.00
	FR30 replication	1.11	14	420	130.82	$0.70
	FR60 replication	2.60	1	60	38.80	$0.10
	FR90 replication	0.00	1	90	116.10	$0.05
	FR5 replication #2		120	600	136.82	$6.00
	FR30 replication #2		14	420	153.69	$0.70

Table 3. Elasticity coefficients, consumption, response output, responses per minute, and money earned during each condition with sound-clips and points/money.

Participant S2						
Reinforcer	Condition	Elasiticity Coefficient	Consumption	Response Output	Responses per Minute	Money Earned
Sound-Clips	FR 5		91	455	58.55	
	FR30	0.30	59	1770	86.83	
	FR60	2.45	6	398	64.53	
	FR90	-2.00	14	1260	72.74	
	FR5 replication		120	600	125.28	
	FR30 replication	1.09	15	450	113?	
	FR60 replication	-0.10	16	960	104.59	
	FR90 replication	1.40	9	810	118.83	
	FR5 replication #2		94	470	115.51	
	FR60 replication #2		9	540	110.99	
Points/ Money	FR5		120	600	70.89	$6.00
	FR30	0.93	24	720	84.14	$1.20
	FR60	0.03	23	1380	63.21	$1.15
	FR90	1.05	15	1350	99.2	$0.75
	FR5 replication		120	600	132.79	$6.00
	FR30 replication	1.05	17	510	137.91	$0.85
	FR60 replication	-0.09	18	1080	124.14	$0.90
	FR90 replication	2.50	6	570	116.54	$0.30
	FR5 replication #2		120	600	134.19	$6.00
	FR60 replication #2		25	1500	101.29	$1.25

Table 4. Elasticity coefficients, consumption, response output, responses per minute, and money earned during each condition with sound-clips and points/money.

Participant S3						
Reinforcer	Condition	Elasiticity Coefficient	Consumption	Response Output	Responses per Minute	Money Earned
Sound-Clips	FR 5	0.00	120	600	58.47	
	FR30		120	3600	146.00	
	FR60	1.80	30	1800	136.94	
	FR90	3.33	6	540	121.07	
	FR5 replication		120	600	264.98	
	FR30 replication	0.18	93	2808	197.61	
	FR60 replication	2.88	2	136	135.59	
Points/ Money	FR5	0.00	120	600	197.43	$6.00
	FR30		120	3600	149.25	$6.00
	FR60	0.14	109	6540	144.41	$5.40
	FR90	4.65	4	360	135.53	$0.20
	FR5 replication		120	600	407.38	$6.00
	FR30 replication	0.00	120	3600	183.39	$6.00
	FR60 replication	1.07	57	3476	174.64	$2.85

Table 5. Elasticity coefficients, consumption, response output, responses per minute, and money earned during each condition with sound-clips and points/money

Participant S4						
Reinforcer	Condition	Elasiticity Coefficient	Consumption	Response Output	Responses per Minute	Money Earned
Sound-Clips	FR 5		41	205	70.96	
	FR30	1.15	4	120	56.95	
	FR60	1.00	2	120	100.24	
	FR90	1.67	1	90	96.70	
	FR5 replication		2	10	73.89	
	FR30 replication	0.47	1	30	97.61	
Points/ Money	FR5		120	600	96.09	$6.00
	FR30	0.00	120	3600	88.80	$6.00
	FR60	1.12	55	3300	*****126.14	$2.75
	FR90	3.46	10	900	83.35	$0.50
	FR5 replication		120	600	113.63	$6.00

***** Response rate is an average of 2 phases of this session
Response rate during phase 1 = 113.62
Response rate during phase 2 = 138.66

Table 6. The number of sound-clips repeated out of the total number of sound-clips consumed at each response requirement, yielding percentage of sound-clip repetition for each participant

Sound-clip Repetition Across Response Requirements for each Participant					
Exposure	Response Requirement	Participants			
		S1	S2	S3	S4
1	FR30	4 out of 63 6.35%	5 out of 59 8.47%	4 out of 120 3%	0 out of 4 0%
	FR60	1 out of 4 25%	0 out of 6 0%	3 out of 30 10%	0 out of 2 0%
	FR 90	0 out of 1 0%	2 out of 14 14.29%	0 out of 6 0%	0 out of 1 0%
2	FR5	3 out of 77 3.90%	5 out of 120 4.17%	13 out of 120 10.83%	0 out of 2 0%
	FR30	0 out of 2 0%	1 out of 15 6.67%	16 out of 93 17.20%	0 out of 1 0%
	FR60	0 out of 1 0%	1 out of 16 6.25%	0 out of 2 0%	~
	FR 90	0 out of 1 0%	5 out of 9 55.56%	~	~
3	FR5	0 out of 3 0%	11 out of 94 11.70%	~	~
	FR30	0 out of 3 0%	~	~	~
	FR60	~	1 out of 9 11.11%	~	~
Total		**8 out of 275 2.91%**	**30 out of 433 6.93%**	**36 out of 491 7.33%**	**0 out of 51 0%**

APPENDIX C

FIGURES

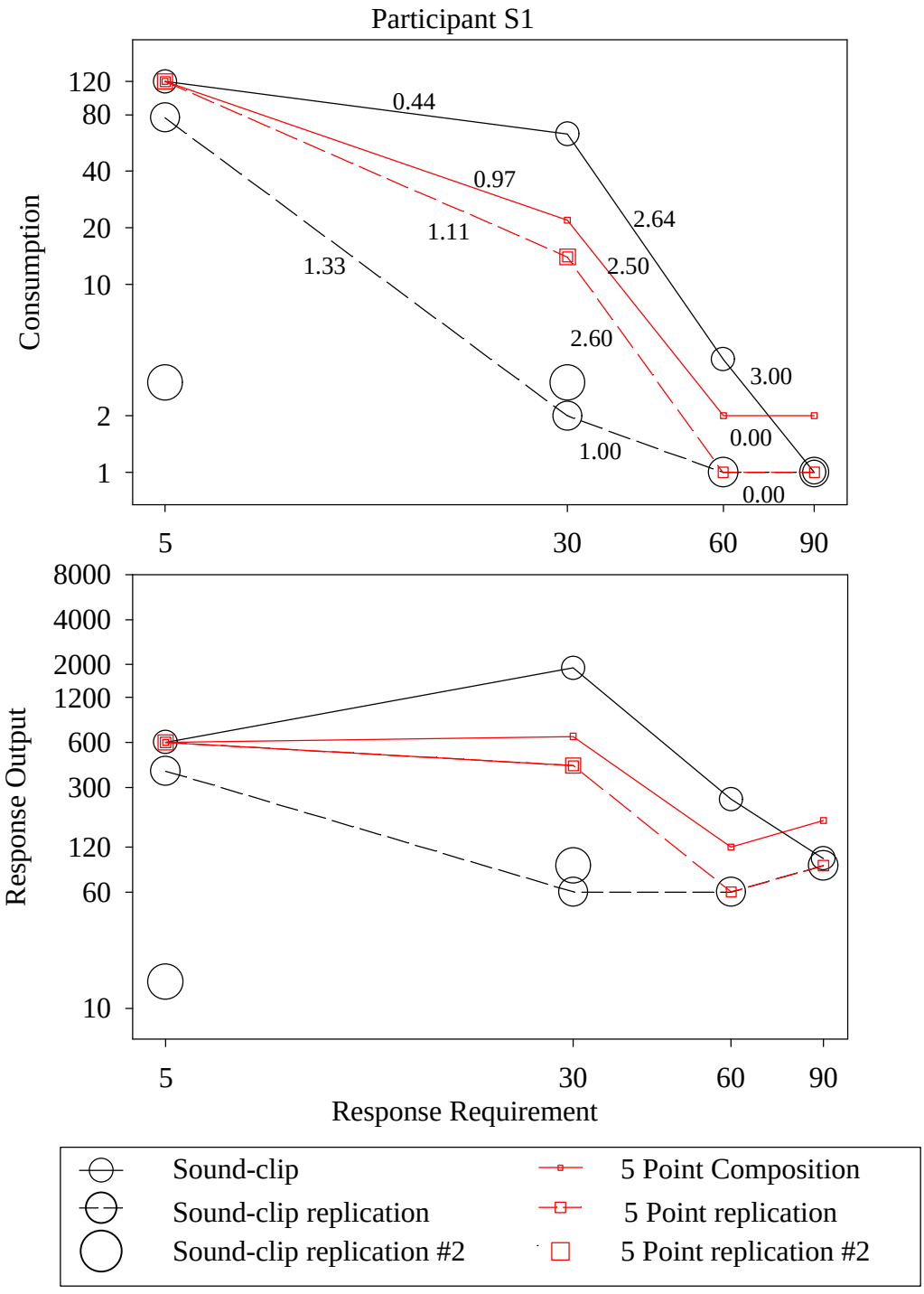

Figure 1. Demand curves (top graph) and response output functions (bottom graph) of sound-clips and points/money. Values next to each demand curve indicate elasticity coefficients.

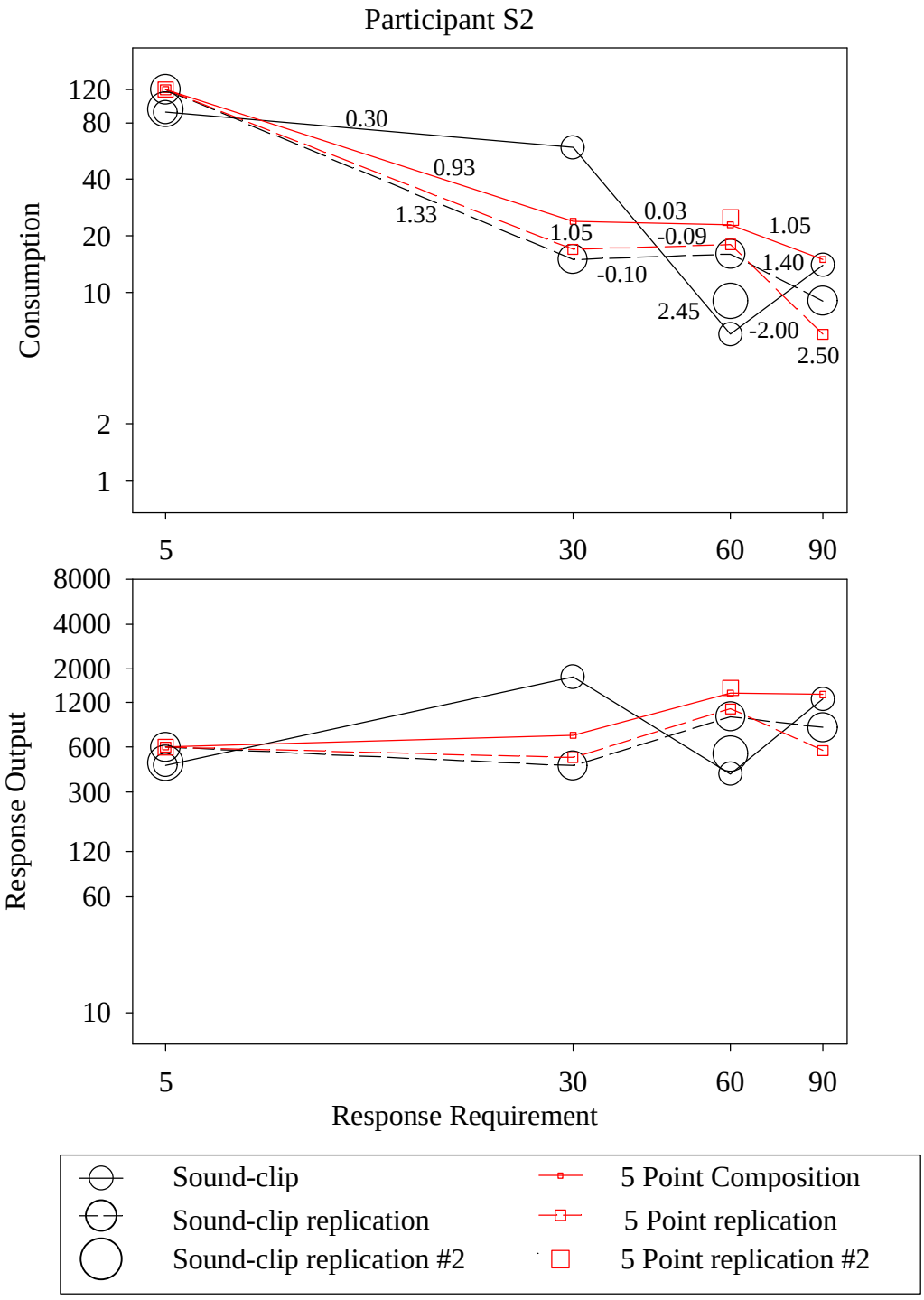

Figure 2. Demand curves (top graph) and response output functions (bottom graph) of sound-clips and points/money. Values next to each demand curve indicate elasticity coefficients.

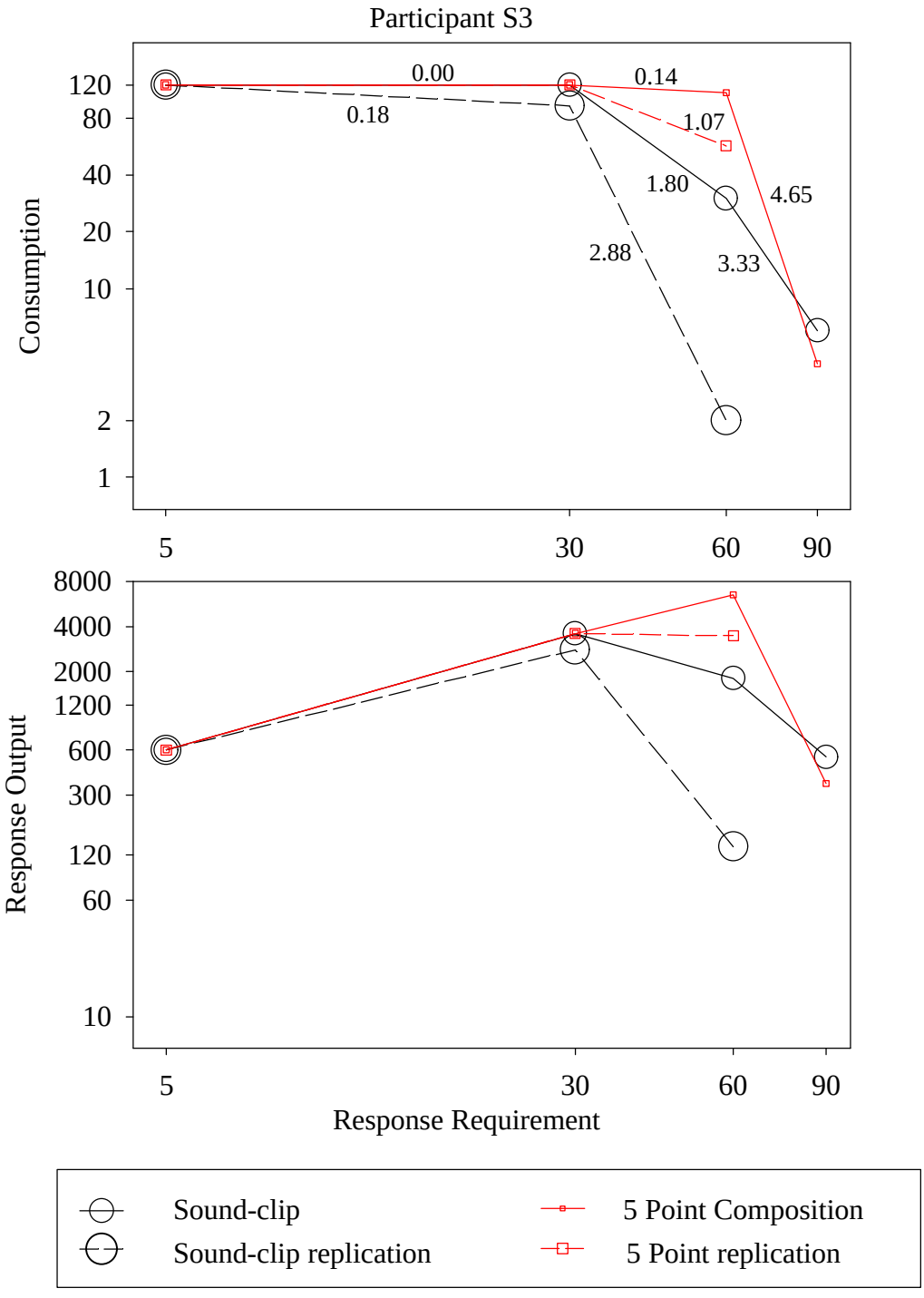

Figure 3. Demand curves (top graph) and response output functions (bottom graph) of sound-clips and points/money. Values next to each demand curve indicate elasticity coefficients.

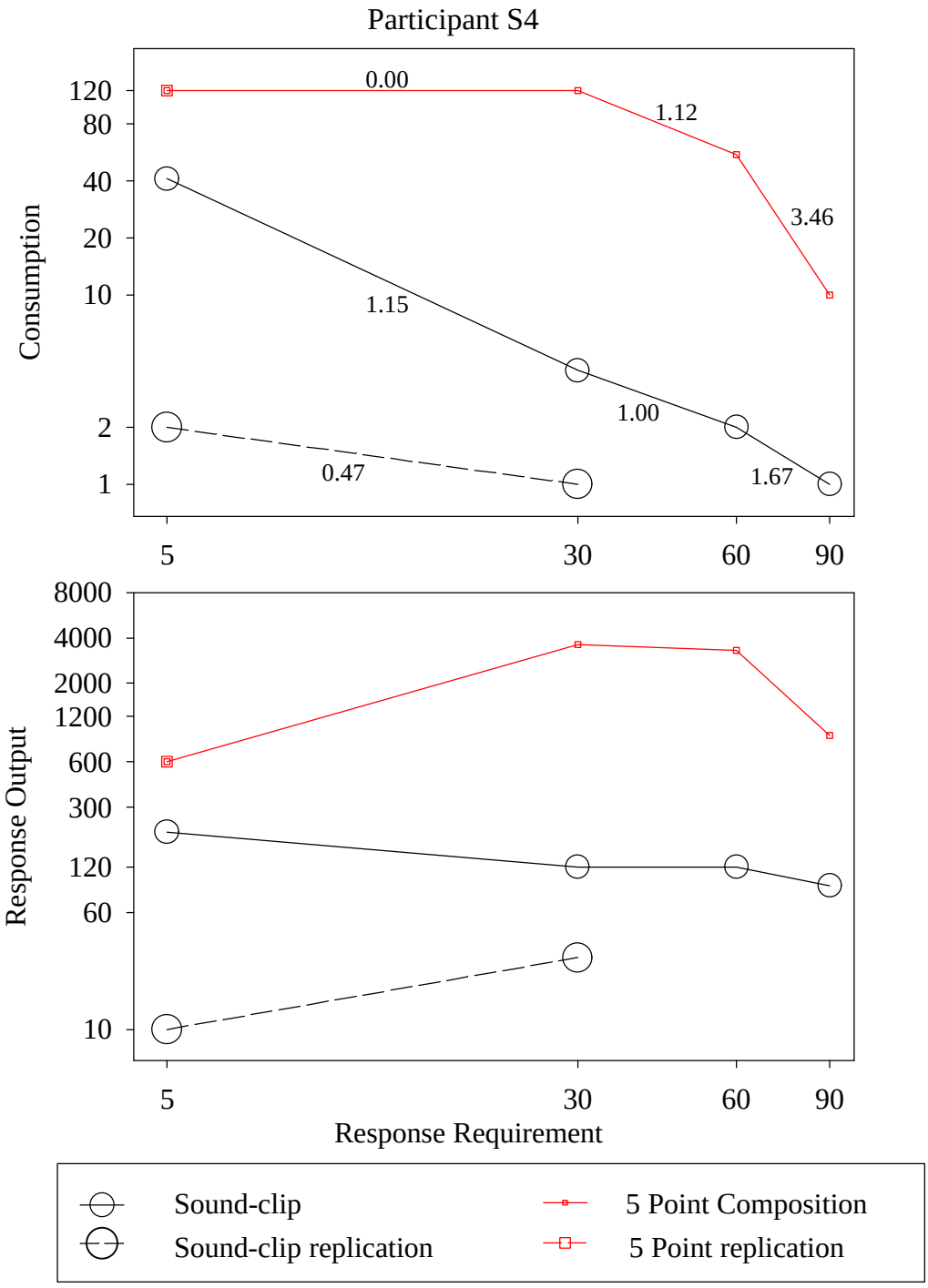

Figure 4. Demand curves (top graph) and response output functions (bottom graph) of sound-clips and points/money. Values next to each demand curve indicate elasticity coefficients.

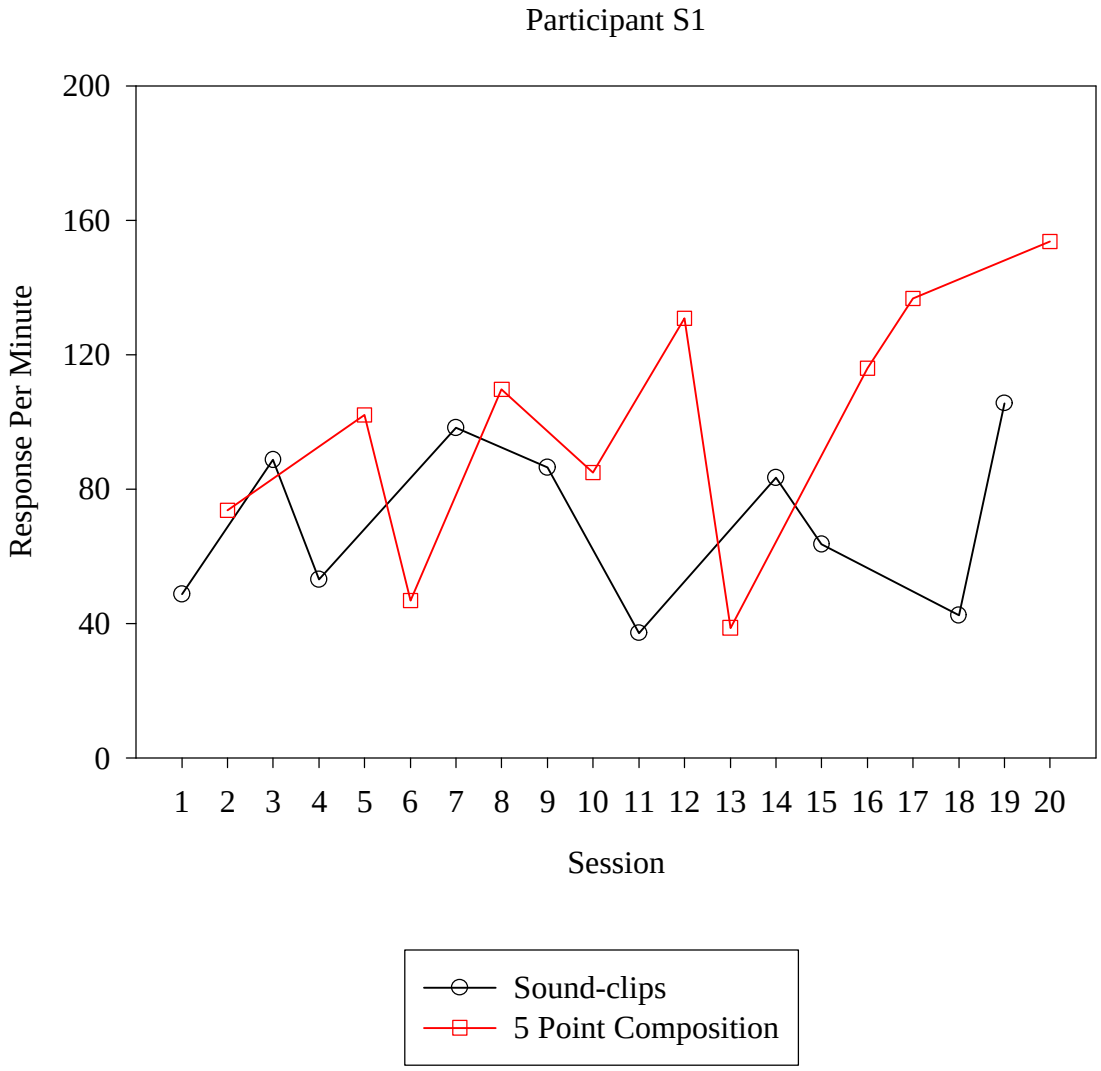

Figure 5. Response rates of sound-clips and points/money across all response requirement sessions.

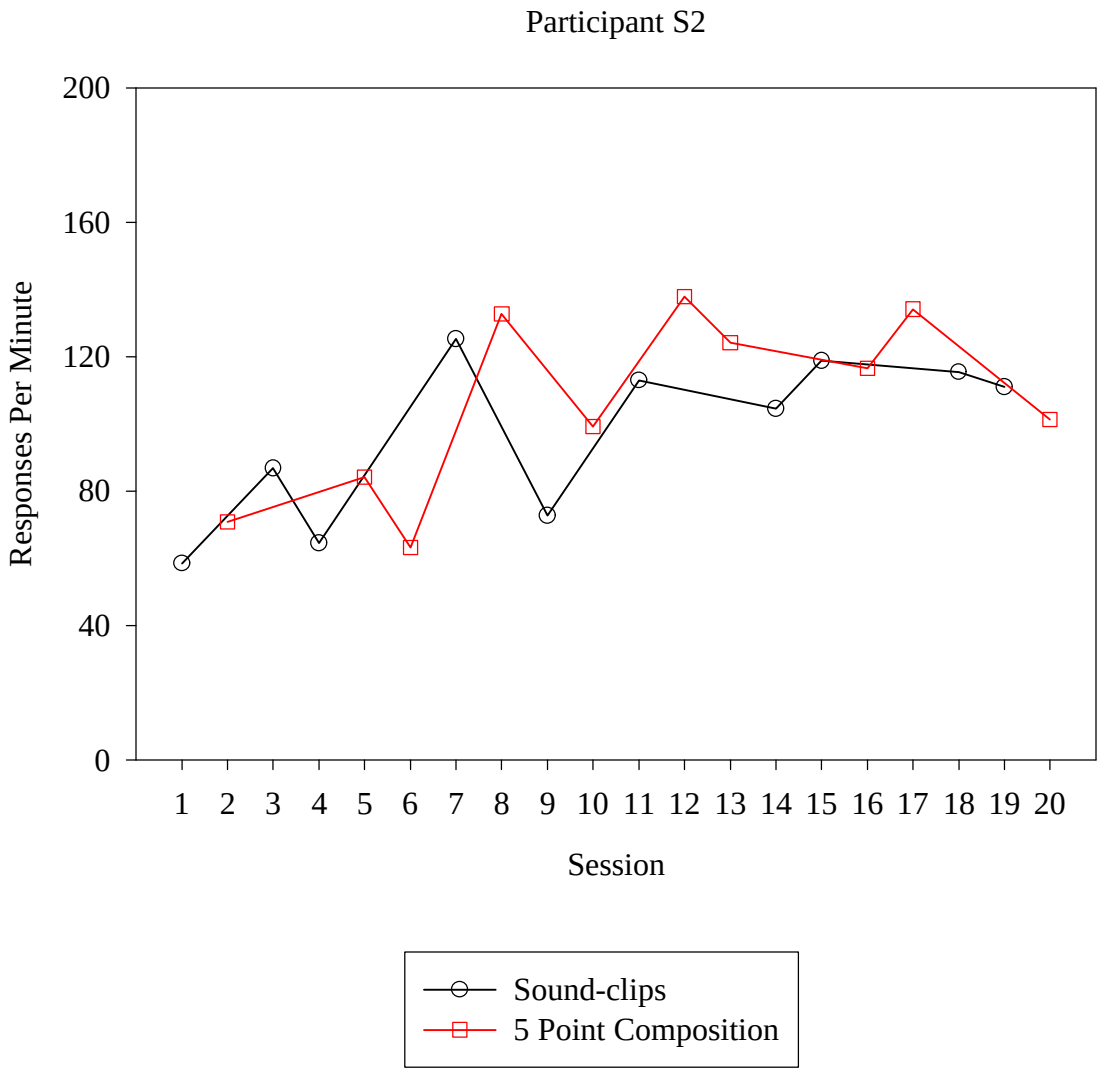

Figure 6. Response rates of sound-clips and points/money across all response requirement sessions.

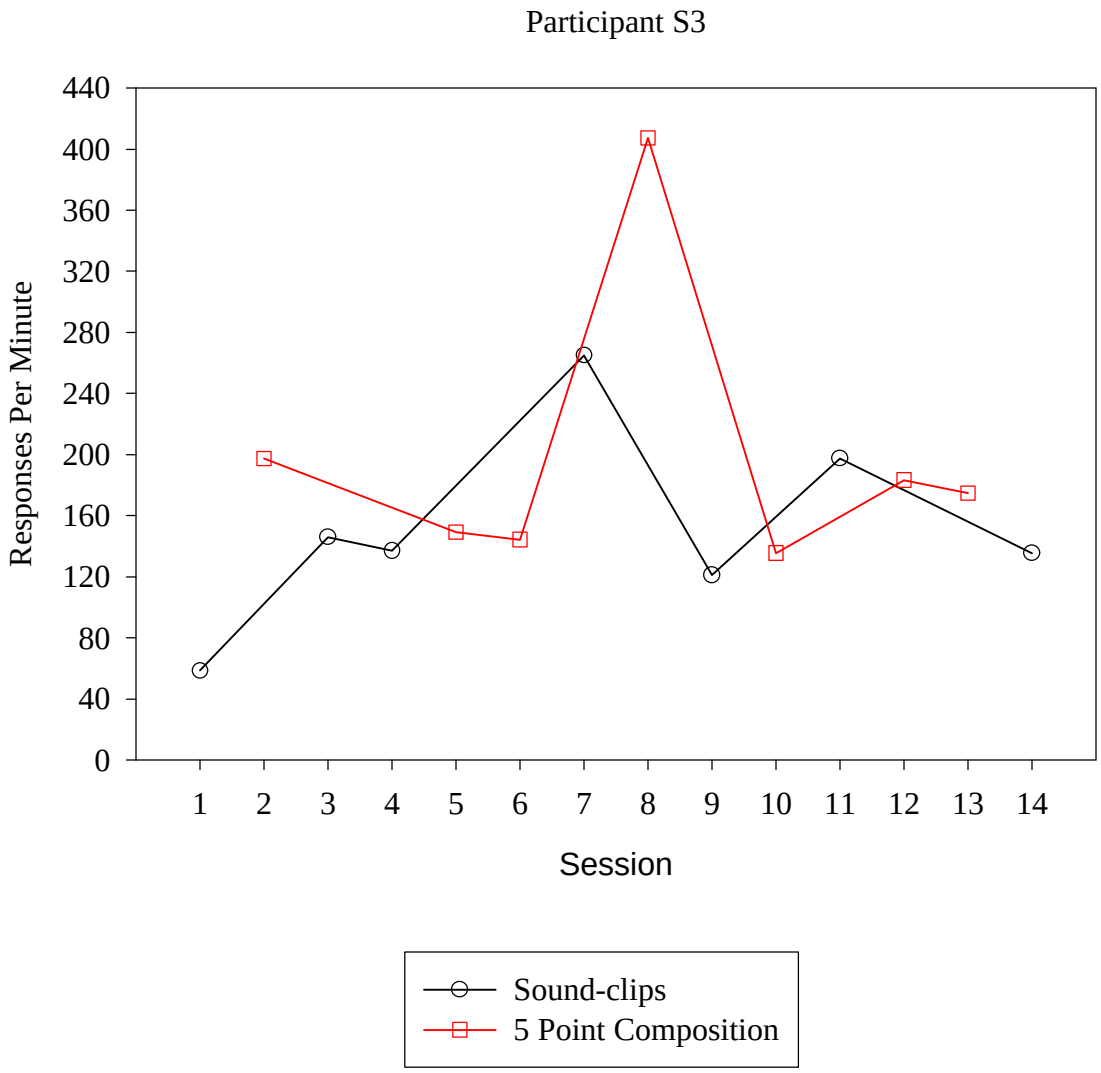

Figure 7. Response rates of sound-clips and points/money across all response requirement sessions.

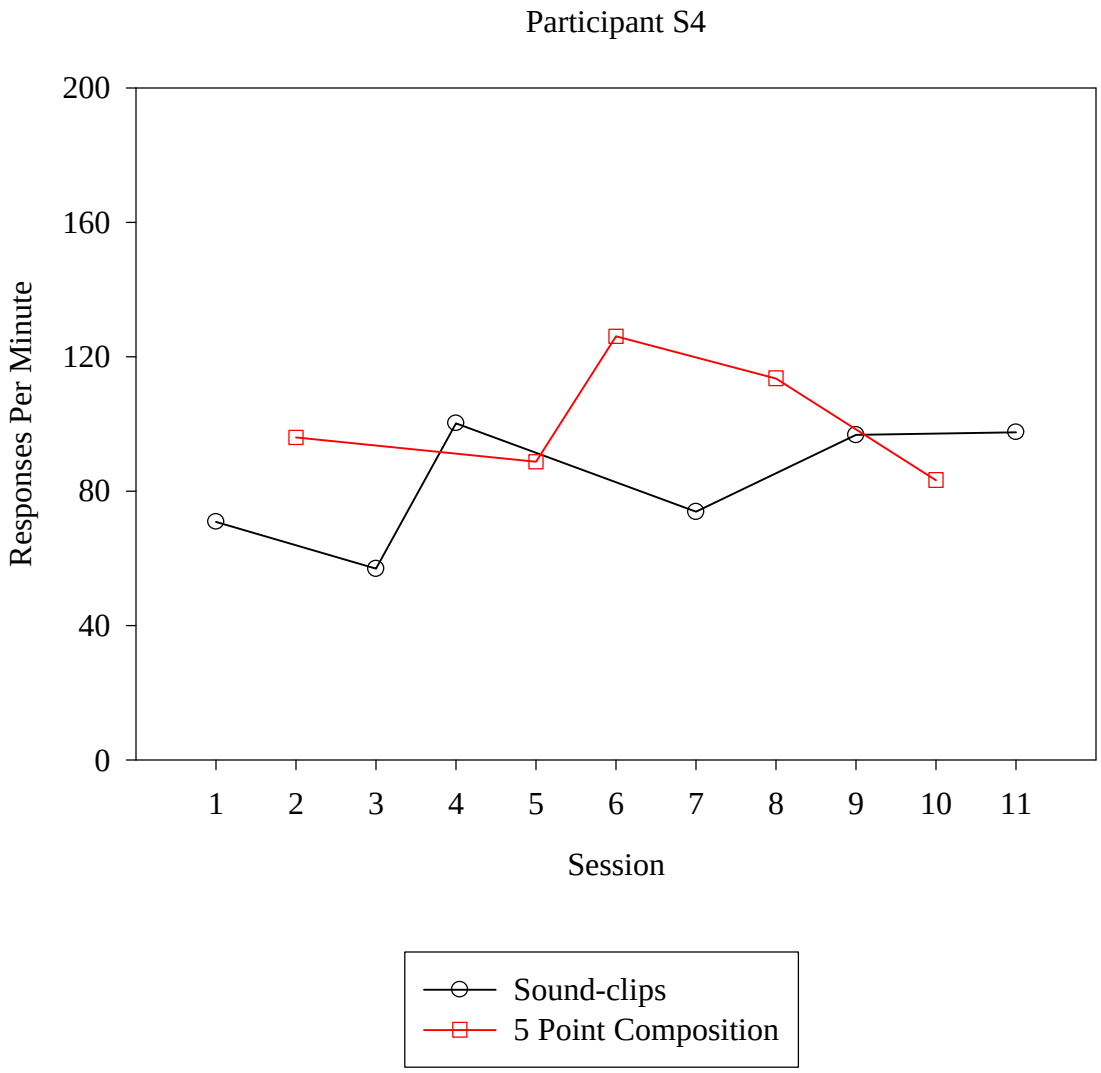

Figure 8. Response rates of sound-clips and points/money across all response requirement sessions.

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